Efficacy of Shipboard Countermeasure Washdown System Against Chemical Warfare Agents

Stefanie Smallwood[1], Shawn Stevenson[1], John Davies[1], Janlyn Eikenberg[1], Michelle Sheahy[1], Dave Gehring[1], Jill Ruth[2], Michael Chesebrough[3], Kevin Morrissey[1]

[1] Combat Capabilities Development Command Chemical Biological Center, Aberdeen Proving Ground, MD; [2] Leidos, Abingdon, MD; DCS Corporation, [3] Abingdon, MD

Introduction

Many naval ships currently use a seawater washdown system to pre-wet and wash away chemical, biological, and radiological contaminants from exterior deck surfaces. For ships that do not have this capability, a reactive solid bleach, detergent, and seawater is the countermeasure employed for hazard mitigation. The focus of the current study was to investigate and optimize reactive decontaminants on exterior naval deck surfaces to reduce hazards to unprotected personnel. The reactive decontaminant composition was optimized using a mixture/process design of experiments (DOE) approach, determining an overall global optimal decontaminant formulation. Four variants of an alternate oxidant, Dahlgren Decon, were evaluated as an alternative to the solid bleach/detergent/synthetic ocean water (SOW) formulation. The four variants showed similar decontamination efficacy values across the variants, and were similar to the efficacy observed for the global optimum formulation. Efficacy of the washdown process on select exterior deck materials results and conclusions will be presented, including details on how the DOE approach was successfully implemented during this project.

Globally Optimal Decon Optimization Study

A limited scope solid bleach/detergent/SOW DOE optimization effort was completed on Navy alkyd topcoat and Navy non-skid test coupons that were subjected to an accelerated curing process (30 days @ 50°C) as recommended by NSWCDD. The 2017 reactive solid bleach/detergent/SOW DOE optimization effort was completed on panels that were not fully cured. The objective of the 2018 limited scope DOE was to determine if the efficacy results from panels which have undergone an accelerated curing process (fully cured) would be similar to the original (not fully cured panel) results. Optimal process factors discovered in the 2017 effort, the agent age time, decon residence time and brushing were locked, while the solid bleach/detergent/SOW formulation and test coupon material type were varied.

		2017 Study (not fully cured material)			2018 Study (fully cured material)		
		Optimal Mixture (%)			Optimal Mixture (%)		
		Solid Bleach	DET[a]	SOW[b]	Solid Bleach	DET[a]	SOW[b]
Navy Alkyd	HD	4.6	0.0^	95.4	3.8	0.0^	96.2
	VX	2.5	1.0	96.5	3.4	0.3^	96.3
	Navy Alkyd Optimal	4.7	1.0	94.3	3.9	0.7	95.4
Navy Non-Skid	HD	4.5	1.0	94.5	5.8	0.0^	94.2
	VX	2.3	1.0	96.7	9.0	1.0^	90.0
	Navy Non-Skid Optimal	5.1	1.0	93.9	7.5	1.0	91.5
GLOBAL OPTIMAL		**5.0**	**1.0**	**94.0**	**5.5**	**0.7**	**93.8**

a. DET is detergent

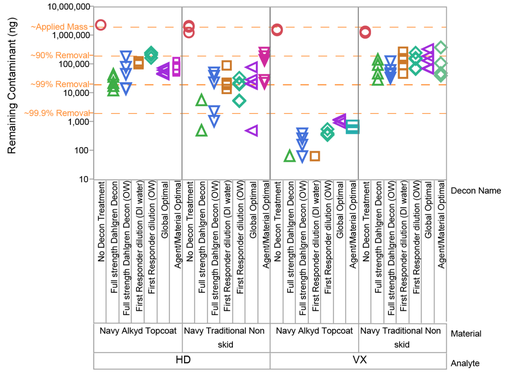
b. SOW is synthetic ocean water

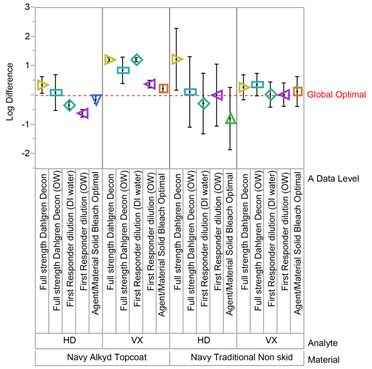
^ Negligible effect on decontaminant performance

Some of the DOE predicted agent/material specific optimals for both the Navy alkyd topcoat and Navy non-skid test panels showed differences in optimal predicted solid bleach and detergent percentages between the FY17 DOE (panels not fully cured) and the FY18 DOE (fully cured panels). Seeing differences was expected based on the decrease in decon efficacy over time that was seen in the 2017 solid bleach optimization study. Incomplete panel curing may have impacted the absorption of contaminants into the material thereby affecting decontaminant performance. However, the global solid bleach/detergent/SOW optimal formulation in the current effort did not deviate substantially from the 2017 solid bleach optimization study. The overall global optimal formulation is 5.5% HTH, 0.7% detergent, and 93.8% SOW.

Decontamination of Exterior Naval Deck Materials Using an Alternate Oxidant

The objective of this effort was to determine the efficacy of alternate oxidant formulations on Navy Alkyd topcoat and traditional Navy non-skid materials, as compared to the currently fielded oxidant, solid bleach. The oxidant chemistry utilized in this effort was Dahlgren Decon in four distinct variations; full strength Dahlgren Decon preparations using either DI water or synthetic ocean water, and a first responders 1:10 Decon to water dilution using either DI water or synthetic ocean water for the dilution. This study mimics the 2017 solid bleach decon optimization effort utilizing the optimal conditions (contaminant age time (5 min), decon residence time (30 min), brushing) from that effort.





The four Dahlgren Decon variations performed similarly within each contaminant-material combination. This study did not demonstrate a statistically significant efficacy difference between the full strength Dahlgren Decon and the 1:10 "First Responders" diluted version. This was true both when the decontaminant was prepared with DI water or simulated ocean water. This finding implies that the first responder's version could potentially have similar chemical decontamination efficacy as the full strength decontaminant, in this application.

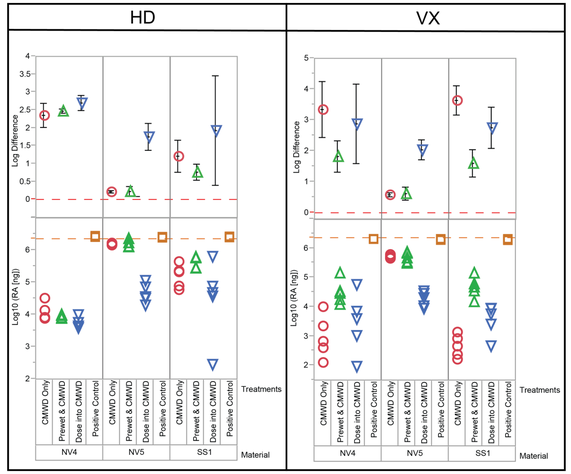
In addition, preparing the decontaminant with simulated ocean water did not appear to impact efficacy in a statistically significant manner. However, those prepared with synthetic ocean water had a noticeable exothermic reaction, evidenced by increases in temperature and added foaming. These observations are indicative of an increase rate of active ingredient degradation, which could lead to decreased pot life, and thus will be investigated further by the team at NSWC Dahlgren Division.
The currently fielded oxidant (solid bleach) and all four Dahlgren Decon variations showed the same efficacy when tested on each contaminant-material pair.

Additional Study: Countermeasure Washdown Efficacy on Newly Employed Shipboard Materials

A 2014 study, conducted at CBC with collaboration from NSWCDD, tested the CMWD system efficacy on the Navy alkyd topcoat and traditional non-skid using contaminant VX. These materials represented the most current fielded shipboard deck materials and the contaminant represented the most current threat knowledge gap to be filled. The overall results from the 2014 study were that while a large portion of contaminant was removed from the surfaces when the CMWD system was deployed, the retained contaminant in the material could still present a hazard to unprotected personnel, and some type of extraction or secondary decontaminant treatment should be performed due to the absorption rate of contaminant into the Navy surfaces.

This study evaluated the efficacy of the CMWD process on new shipboard deck surfaces Navy 2-part polysiloxane and peel-and-stick nonskid with contaminants HD and VX to mimic the previous effort outlined in CB-2377 CMWD.

The panel treatments aimed to emulate scenarios in which the CMWD may actually be used. The positive controls mimic the scenario in which the CMWD is not used. The CMWD only replicates the condition in which the system is applied after a chemical agent exposure. The pre-wet and direct contamination into the CMWD provide variations of the scenario in which the CMWD is running prior to and during a chemical agent exposure event.



Although the remaining contaminant was greatly decreased, the amount of retained contaminant indicates that the absorption of the contaminant into the Navy materials can occur in seconds following contamination. Further investigations are recommended to determine how to mitigate the quickly absorbed residual contaminant.

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